PHYTOTOXICOLOGY ASSESSMENT SURVEY INVESTIGATION IN THE VICINITY OF ALLIED CHEMICAL CANADA LIMITED AMHERSTBURG, 1986

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Phytotoxicology Assessment Survey Investigation in the Vicinity of Allied Chemical Canada Limited, Amherstburg - 1986

Phytotoxicology Section
Air Resources Branch

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SUMMARY

Allied Chemical Canada Limited initiated production of hydrofluoric acid (HF) at its Amherstburg plant in 1970. Since then, the Phytotoxicology Section has maintained an annual program to monitor visible injury and fluoride content of maple foliage and grass near the facility.

Elevated fluoride values found in the foliage and grasses prompted the Ministry to issue a Control Order against the company in 1980. The Order stipulated the values of fluoride in washed maple foliage and not-washed grasses which were not to be exceeded. Prior to the 1981 growing season, the Order was rescinded.

Since 1981, violations of the former Control Order have occurred in both maple foliage and grasses, although the number of violations have been variable.

In 1986 there would have been no violations of the former Control Order in grasses, however, four violations would have occurred in the washed maple foliage.

The Phytotoxicology Section also monitors the performance of the HF plant according to a fluoride upper limit of normal guideline for urban foliage. Out of 40 site/surveillance possibilities, fluoride values were above the Phytotoxicology guideline on 21 occasions in 1986. The number of 1986 occasions was lower than the 34 of 1985 and the 26 of 1984.

Overall, the average all-station monthly fluoride averages for both washed and not-washed foliage were lower in 1986 than in 1985. In spite of the apparent 1986 decline, values of both the washed and not-washed maple foliage continued to exceed the specifications of the former Control Order and the Phytotoxicology guideline at some survey sites.

RÉSUMÉ

L'Allied Chemical Canada Limited a commencé à produire de l'acide fluorhydrique à son usine d'Amherstburg en 1970. Depuis, la Section de phytotoxicologie analyse chaque année le feuillage des érables et l'herbe dans les environs en vue d'analyser leur teneur en fluorure et de déterminer s'ils sont endommagés.

En 1980, le Ministère a délivré un arrêté d'intervention à la société, car on avait mesuré des concentrations élevées de fluorure dans l'herbe et le feuillage. Cet arrêté fixait les concentrations à ne pas dépasser dans le feuillage lavé et dans l'herbe non lavée. Il a été annulé avant la saison de végétation de 1981.

Depuis 1981, la société a dépassé les seuils prescrits par l'ancien arrêté et dans l'herbe et dans le feuillage des érables, quoique le nombre de fois ait varié d'une année à l'autre.

En 1986, l'ancien arrêté aurait été respecté en tous points dans le cas de l'herbe, mais il aurait été violé à quatre reprises dans celui du feuillage des érables.

La Section de phytotoxicologie surveille également le rendement de l'usine du point de vue de la concentration maximale admissible de fluorure en milieu urbain. Il y a 40 postes d'échantillonnage possibles. En 1986, la concentration de fluorure était supérieure 21 fois à la ligne directrice établie par la Section de phytotoxicologie. Ce chiffre était cependant plus bas que celui de 1985 (34) ou de 1984 (26).

Dans l'ensemble, la concentration moyenne de fluorure par mois à tous les postes réunis, aussi bien pour le feuillage lavé que pour le feuillage non lavé, était moins élevée en 1986 qu'en 1985. Malgré la diminution qui semble s'être produite en 1986, cependant, la concentration mesurée à la fois dans le feuillage lavé et dans le feuillage non lavé des érables était supérieure à quelques endroits au seuil que fixait l'ancien arrêté d'intervention et à la ligne directrice de la Section de phytotoxicologie.

1. Introduction

Since the early 1900's, soda ash and calcium chloride have been produced at the plant formerly controlled by Allied Chemical Canada Limited (ACCL). In 1970, the company completed a new facility for the manufacture of hydrofluoric acid (HF). During the initial year of production, the Ministry of the Environment established bio-monitoring plots of gladiolus (var. Snow Princess) in the vicinity of the company property during the summer to monitor emissions from the new HF plant.

In addition, a network of silver maple and grass monitoring sites were established near the Allied complex to monitor both salt-related and fluoride emissions from the diversified chemical plant. This surveillance of vegetation has been continued annually to the present.

Because of the possible interference of salt emissions from the Allied complex, the differentiation between visible fluoride and salt-induced foliar injury has been difficult, and therefore, not attempted. Rather, maple foliage at each survey site has been systematically evaluated during each surveillance visit since 1981 to determine the severity of all industrially-induced foliar injury. The implication of either salts and/or fluoride in the injury observed or taken up by the foliage has ultimately been determined by chemical analysis.

In 1986, the soda ash and other related plant operations were acquired by General Chemical Canada Limited. Ownership and operation of the HF manufacturing facility was retained by Allied Chemical Canada Limited.

2. Hydrogen Fluoride Manufacturing Plant Upsets

Two events relating to the HF operation were reported to the Ministry in 1986. On December 1, approximately 20 tons of liquid oleum were lost during unloading into the HF complex. Although the liquid was reportedly contained within a dyked area, resulting gaseous clouds were apparently carried by northeast winds toward the Detroit River. Because of the winter season, no complaints of sulphur or acid-type vegetation injury were received.

Allied Chemical reported a minor release of HF gas to the atmosphere during the early hours of July 6. The discharge apparently lasted only a few minutes. No complaints of vegetation injury were received by the Ministry as a result.

3.0 Monthly Maple Foliage and Grass Surveillance Visits

3.1 Visual Evaluation of Maple Foliage

The Phytotoxicology surveillance of foliage has traditionally been conducted at 10 established sites in close proximity to the Allied and General Chemical plants (Figure 1). Annually, at the end of each month from May to September, maple foliage has been inspected for evidence of air pollution injury and then sampled for chemical analysis. At two sites (33 and 50) Manitoba maples have been substituted because of the unavailibility of silver maple. Actual sample dates and Phytotoxicology investigators appear in Table 1.

During each of the 5 month-end surveillance visits in 1986, a complete visual examination of maple foliage at each of the 10 survey sites was undertaken. Any injury considered to be industrially induced was assigned anaverage percent injury value based on a universal scale employed by the Phytotoxicology Section.

Because of the close proximity of Allied Chemical to General Chemical, and the nature of activity at both plants, the possibilities of both salt and fluoride emissions might be expected. Because injury symptomatology can be similar in expression, no attempt has been made since 1982 to differentiate injury symptomatology between the two. Natural disorders attributed to insects, disease or physiological problems were excluded from the injury assessments. The 1986 visual injury evaluations, along with those for the years 1981 to 1985, have been assembled in comparative form in Tables 2-6.

During the first visit in May of 1986, trace levels of injury were observed on maple foliage at site 29. No injury was found at any of the remaining 9 survey locations. (Table 2)

Similarly, only trace levels of injury were found at site 29 during the June, 1986 evaluation. Compared with the previous year, 1986 injury levels were generally much lower. (Table 3)

In July, trace levels of industrially-induced injury was observed at 4 survey sites. The severity levels of injury at 3 of the sites remained unchanged from those of 1985. (Table 4)

Injury ratings at the end of August 1986 (Table 5) showed some improvement at 6 of the 8 sites from the previous year. At site 18, the 1985 injury evaluation of light injury (2-10%) dropped to zero in 1986. At site 16, an injury rating of moderate severity (11-35%) was assessed in 1985 but in 1986 was evaluated as light. A significant decrease was also noted at site 31. In 1985, injury was rated as moderate, but in 1986, the injury severity was light.

The final evaluation of the 1986 summer season was conducted at the end of September. Comparative evaluations in Table 6 show that the injury rating at site 16 was slightly more severe in 1986 than in 1985. At site 31, no change in injury severity has occurred since the previous year.

The practice of collecting and preserving representative samples of injured maple foliage for documentation purposes was continued in 1986. This collection of injured specimens is intended to provide a historical perspective of injury severity and the symptomatology observed.

Unlike the maple foliage, injury symptom observations and evaluations were not performed on the grasses at any surveillance location. Because the grass areas are cut regularly at most locations the remaining stubble is unsuitable for injury evaluation.

3.1.2 Maple Foliage Collection

Following the observational phase of each month-end visit to each

of the 10 surveillance sites, true triplicate samples of maple foliage were obtained from the side of each tree facing the Allied plant for purposes of chemical analysis. A single sample of the foliage was obtained by Allied representatives for independent analysis.

Each Phytotoxicology triplicate sample was collected in clean, new plastic bags and returned to the Toronto laboratory for processing. Because of the maple foliage **washed** and **not washed** designations, each of the triplicate samples was divided into two halves. One half received the **wash** procedure while the other half was processed as **not washed**. Following these steps, all samples were dried and ground in a Wiley mill.

Processed samples were then forwarded to the Ministry's Inorganic Trace Contaminants laboratory for the determination of fluoride, sodium, chloride and calcium levels of the leaf material.

3.1.3 Grass Collection

At each of the 10 Phytotoxicology surveillance sites, true triplicate samples of grasses were obtained at the end of each month from April to October for chemical analysis. Each collected sample was stored in a clean, new plastic bag and returned to the Phytotoxicology processing laboratory in Toronto. At each site, the Allied field representative collected a single grass sample for separate analysis in the company laboratory. Grass collection dates and Phytotoxicology investigators names also appear in Table 1.

All Phytotoxicology grass samples were subjected to the standard **not-washed** process, dried and ground in a Wiley mill. Completed samples were then submitted to the Inorganic Trace Contaminants laboratory for fluoride, sodium, chloride and calcium analysis.

4.0 Chemical Analysis Results

Fluoride values found in **washed** and **not-washed** maple foliage during each of the 5 surveillance visits in the vicinity of Allied Chemical have been listed in Table 7. Fluoride values found in the not-washed grasses during each of the 7 month-end visits are shown in Table 8. Although triplicate samples were collected and analyzed, fluoride values for each site in the Tables represent the average of the triplicates.

With respect to fluoride emissions from the Allied HF plant, the abatement performance of the operation is determined by the Phytotoxicology Section by two methods.

The first compares fluoride values found in the sampled **washed** maple foliage and **not-washed** grasses with the specifications outlined in a Control Order issued in 1980 but rescinded prior to the 1981 sampling season. The former Order specified that dry weight concentrations of fluoride in **not- washed** grasses collected near the Allied plant were not to exceed 80 ppm on a monthly average (average of two samplings near the beginning and end of the month). Further, concentrations were not to exceed 60 ppm on a two consecutive-month average (average of 3 samplings). With

respect to **washed** maple foliage, fluoride concentrations were not to exceed 100 ppm in any single monthly sampling period.

The second method references fluoride levels found in **not-washed** vegetation (not grasses) with the fluoride level contained within the Phytotoxicology Guideline of the upper limits of normal for the element. The guideline represents the 'upper limit of normal' concentration of fluoride in samples collected from areas of Ontario (urban and rural) not subject to the influence of point sources of emissions. The fluoride guideline represents the mean of available analytical data plus three standard deviations of the mean. Assuming results are normally distributed, 99% of all contaminant levels in samples from 'background' areas (not affected by point sources) will lie below these upper limits of normal. Concentrations, therefore, which exceed the guideline are indicative of pollution, whether it be from an identifiable source or due to an unknown cause. In the case of fluoride, **not-washed** values above 35 ppm are in excess of the upper limits of normal guideline.

Visual injury to vegetation is another method used to determine the presence and possibly the nature of an industrial air pollutant. However, in the case of the Allied Chemical surveillance this method has not been employed because of another nearby point source of emissions which could contribute to erroneous interpretations of injury symptomatology.

With particular reference to specifications contained within the former Control Order, Table 9 lists the number of exceedences recorded for grasses and **washed** maple foliage from 1980 to 1986. The number of exceedences show a considerable range of variability over the 7 year period.

Table 10 lists the number of exceedences that would have occurred according to the Former Control Order and the actual values registered for grasses in 1985 and 1986. Nine exceedences would have occurred in 1985 but none in the 1986 grasses.

The 100 ppm fluoride concentration specified for **washed** maple foliage in the former Control Order would have occurred on 4 occasions in 1986. (Table 8) Table 11 indicates that 3 of the violations would have occurred at sample site 1 and once at site 16. The highest values were found at site 1 during the last 3 surveillance visits of the growing season.

Also shown in Table 11 are the actual values of the 6 exceedences which would have taken place in the 1985 **washed** maple foliage. As in 1986, site 1 was most adversely impacted with 4 possible violations registered.

The existing Phytotoxicology upper limits of normal guideline for fluoride in **not-washed** urban foliage is 35 ppm. Table 12 lists the 21 exceedences of the guideline and the actual values according to sample location and sampling date in 1986. The Table shows that fluoride levels were over the Phytotoxicology guideline during all five sampling occasions at survey site 1.

By comparison, 1985 fluoride values in **not-washed** vegetation exceeded the guideline on 34 occasions. (Table 13) At sample sites 16, 18,

29, 31 and 1, fluoride values were above the guideline on each of the 5 sampling dates. In 1984, fluoride values above the Phytotoxicology guideline were found in 26 instances. (Table 14) Exceedences on each of the five sampling dates was only found at site 1.

Clearly, Tables 12, 13 and 14 demonstrate that the highest fluoride values found in **not-washed** maple foliage during the period from 1984 to 1985, were at survey site 1. The summary of site exceedences for the three year period has been prepared in Table 15. On each of the 15 sample occasions, fluoride values at site 1 exceeded the Phytotoxicology guideline. Fourteen exceedences were noted at site 31 during the 15 sample occasions.

Tables 16-20 show fluoride values found in **washed** silver maple and Manitoba maple foliage sampled from May to September for the years 1975 to 1986. Also listed are the all-station yearly mean values for each of the years. In order to compare recent values with those from the earlier years, data from the more recently established survey sites (32 and 33) have not been included in the mean determinations.

An average fluoride concentration of 40 ppm was found in the **washed** maple samples at 6 survey sites in May, 1986. This level was considerably lower than the 65 ppm of 1985 and slightly lower than the 1975-1985 average of 49 ppm. (Table 16)

The June, 1986 average of 42 ppm was slightly lower than the 1985 average of 46 ppm and the 1975-1985 average of 48 ppm. (Table 17)

The July, 1986 average of 41 ppm was considerably lower than both the 1985 average of 64 ppm and the 1975-1985 average of 60 ppm. (Table 18)

Washed maple foliage collected from 6 survey sites at the end of August, 1986 averaged 96 ppm. This 1986 figure was much greater than the 1985 average of 63 ppm and higher than the eleven year average of 76 ppm. (Table 19)

The September, 1986 average for fluoride in **washed** maple foliage was 80 ppm. This value was lower than both the 1975-1985 average of 95 ppm and the 1985 average of 92 ppm. (Table 20)

Clearly, the highest fluoride values in **washed** maple foliage continue to be found at site 1. According the prevailing summer wind directions, this location is located downwind from the HF manufacturing facility.

Monthly all-station fluoride values in **washed** silver maple for the years from 1981 to 1986 have been assembled in Table 21. The 60 ppm seasonal average is slightly lower than the averages of the previous 3 years but similar to the 1981-1985 average of 57 ppm.

Average all station (except control sites 12 and 50) fluoride levels found in both **washed** and **not-washed** maple foliage from 1975 to 1986 have been assembled in Table 22. Average yearly fluoride concentrations found in sampled grasses from from 1982 to 1986 have also been included in Table 22.

Both the **washed** and **not-washed** average values for 1986 were lower than their respective counterparts in 1985. The most significant decrease occurred in the **not-washed** value. In 1985, the average value was 102 ppm but only 75 ppm in 1986. In spite of the decrease of 1986 **not-washed** average values, it should be noted that the 75 ppm value is considerably above the 35 ppm Phytotoxicology upper limit of normal guideline.

The concentration ratio between the 1986 washed and not-washed maple foliage was 1:4. This ratio is lowest since 1975 and lower than the 1975-1985 average ratio of 1:8.

The 33 ppm fluoride average found in the 1986 grasses was noticeably lower than the 40 ppm of 1985.

5.0 Annual Comprehensive Maple and Grass Surveillance

The regular Phytotoxicology surveillance of maple foliage and grasses is conducted annually at sites located relatively close to the Allied complex. However, in order to determine the extent of emissions over a broader area, the Ministry has conducted one annual survey of vegetation at 20 established additional outlying sites.

The 1986 surveillance was conducted on September 3 and 4 at the 20 locations shown in Figure 1. Triplicate samples of silver maple or Manitoba maple and grasses were collected and submitted for fluoride, sodium, chloride and calcium analaysis. Data pertaining to the comprehensive survey of 1986 have been received and when collated with results from previous surveys, all the data will be reported.

6.0 Complaints

The Phytotoxicology Section received and investigated a total of 14 complaints of vegetation injury from residents living at locations in relatively close proximity to both the Allied Chemical and General Chemical plants. Field investigation and subsequent chemical analysis of collected foliar samples determined that vegetation injury, directly attributable to industrial emissions, occurred in only one case. Because of the low fluoride levels found, however, emissions from the Allied plant were not believed to be implicated.

7.0 Conclusions

With respect to the impact on vegetation, the relative performance of the Allied Chemical hydrogen fluoride manufacturing facility is determined according to several methods. The first compares fluoride levels found in sampled **washed** maple foliage and not-washed grasses near the plant with specifications contained within a former Control Order. With the second method, fluoride values found in **not-washed** maple foliage are compared with the upper limit of normal Phytotoxicology guideline for the element.

According to the specifications contained in the former Control

Order, none of the 1986 fluoride values found in sampled grasses would have been in excess. In 1985, 9 violations would have occurred.

Fluoride values for **washed** maple foliage indicated that violations of the former Order would have occurred on 4 occasions in 1986. This number was down slightly from the 6 of 1985. Three of the four highest 1986 values occurred at surveillance site 1, which is located downwind from the hydrogen fluoride plant.

With respect to the Phytotoxicology upper limit of normal guideline for fluoride, the number of 1986 values above the guideline dropped to 21 from 34 in 1985. Clearly, the survey locations with the greatest number of exceedences and the highest values are immediately north (site 1) or south (site 16) of the plant

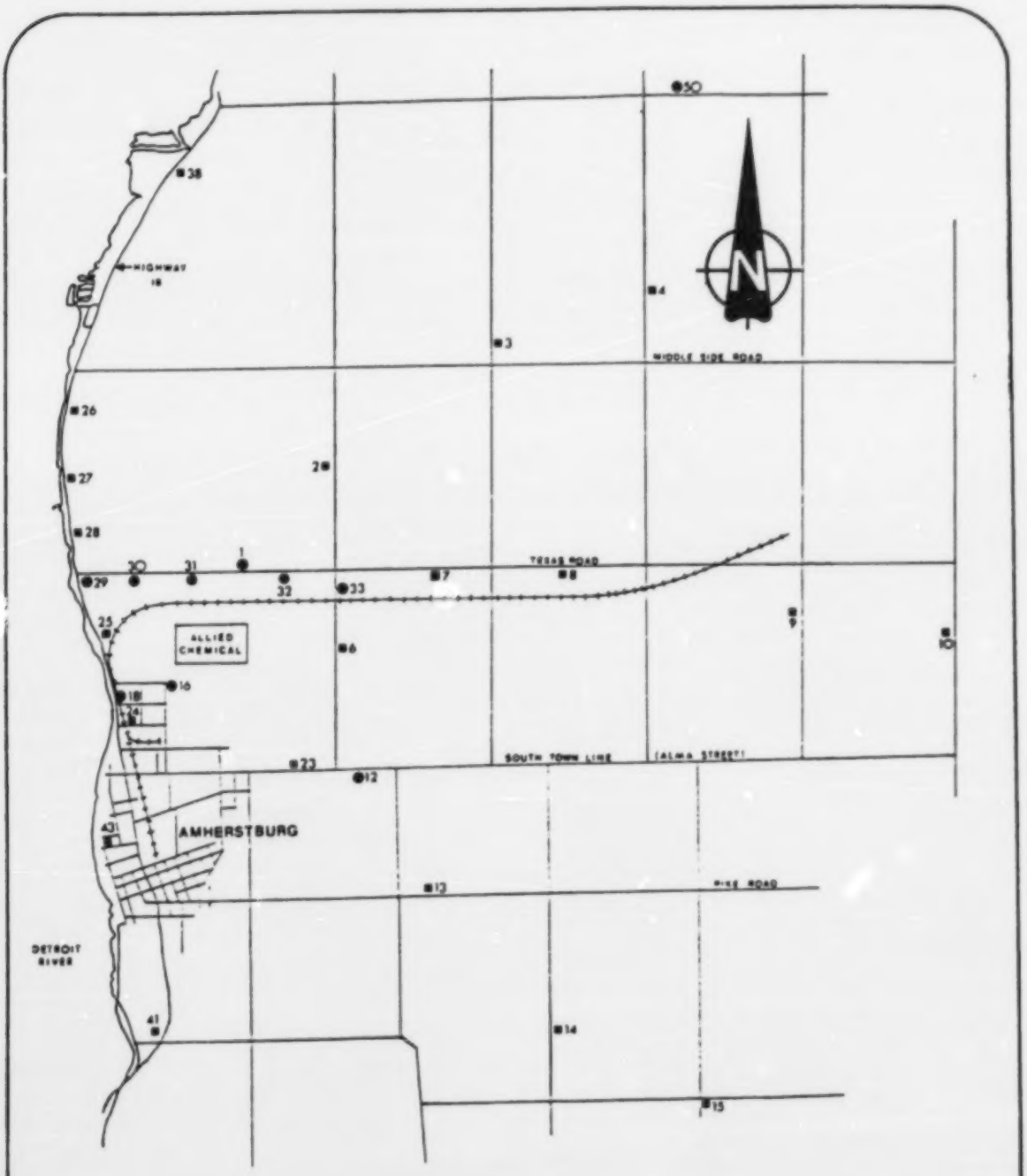
Although 14 complaints of vegetation injury were received and investigated by the Phytotoxicology Section in 1986, none was associated with fluoride emissions from the HF plant.

With the exception of August, the monthly all-station 1986 fluoride averages were all lower than during the same periods in 1985. Similarly, the 1986 all-station seasonal average of 60 ppm was the lowest since 1982.

In summary, the all-station monthly averages for **washed** and **not-washed** foliage were lower in 1986 than in 1985. Nevertheless, values of both the washed and not-washed maple foliage continue to exceed some of the specifications of the former Control Order and the Phytotoxicology upper limit of normal guideline at some survey locations.

Other than a minor release of hydrogen fluoride in July, no major production upsets or accidental emissions were reported to the Phytotoxicology Section. It must be concluded, therefore, that the elevated fluoride levels found in vegetation at some of the survey sites resulted from a gradual accumulation of ongoing fluoride emissions from the Allied Chemical plant.

FIGURE: 1 Locations of 10[1] Phytotoxicology Grass and Maple Surveillance Locations Sampled Monthly from May to October, 1986 in the Vicinity of Allied Chemical Canada, Limited, Amherstburg



[1] ● - Grass sampled monthly from April to October at 10 locations
● - Maple foliage sampled monthly from May to September at 10 locations
■ - Grass and maple foliage sampled on one occasion at 20 locations

TABLE 1

Phytotoxicology Grass and Maple Foliage Surveillance Dates
in the Vicinity of Allied Chemical Canada Limited

1986

Surveillance Date	Surveillance Vegatation	Phytotoxicology Investigators
April 29	Grass	A. Enyedi
May 28	Grass & Maple Foliage	G. Vasiloff & M. Mallette
July 2	Grass & Maple Foliage	G. Vasiloff & P. McGovern
August 1	Grass & Maple Foliage	G. Vasiloff & D. McLaughlin
September 4	Grass & Maple Foliage	G. Vasiloff
September 3 & 4	Grass & Maple Foliage Survey at 20 additional outlying sites	G. Vasiloff, W. Gizyn A. Kuja
October 2	Grass & Maple Foliage	G. Vasiloff
October 29	Grass	G. Vasiloff & D. Harper

RE1357

Table 2

Visual Injury Rating[1] of Air Pollution-Induced Symptoms on Silver Maple[2] Foliage Collected during May in the Vicinity of Allied Chemical, Amherstburg[3]

1981 - 1986

Sample Station Number	Foliar Injury Severity					
	1981	1982	1983	1984	1985	1986
16	Tr	0	Tr	Tr	Tr	0
18	Tr	Tr	Tr	Tr	0	0
29	0	Tr	Tr	Tr	Tr	Tr
30	0	Tr	Tr	Tr	Tr	0
31	Tr	Tr	Tr	S	Tr	0
1	Tr	Tr	Tr	Tr	Tr	0
32	-	-	0	Tr	Tr	0
33	0	0	Tr	Tr	0	0

0	-	0%
Trace	-	>0-1%
Light	-	2-10%
Moderate	-	11-35%
Severe	-	>35%

[1]Value represents total injury - no differentiation has been made between fluoride and/or salt symptomatology

[2]Manitoba maple sampled at stations 33 and 32

[3]Control locations 12 and 50 not included

RE1357.1

Table 3

Visual Injury Rating[1] of Air Pollution-Induced Symptoms on Silver Maple[2] Foliage Collected during June in the Vicinity of Allied Chemical, Amherstburg[3]

1981 - 1986

Sample Station Number	Foliar Injury Severity					
	1981	1982	1983	1984	1985	1986
16	Tr	Tr	Tr	Tr	Tr	0
18	Tr	Tr	Tr	Tr	M	0
29	Tr	Tr	Tr	Tr	L	Tr
30	0	Tr	Tr	L	Tr	0
31	Tr	Tr	Tr	S	M	0
1	Tr	Tr	Tr	L	L	0
32	-	-	0	Tr	Tr	0
33	0	0	0	0	Tr	0

0	-	0%
Trace	-	>0-1%
Light	-	2 - 10%
Moderate	-	11 - 35%
Severe	-	>35%

[1]Value represents total injury - no differentiation has been made between fluoride and/or salt symptomatology

[2]Manitoba maple sampled at stations 33 and 32

[3]Control locations 12 and 50 not included

RE1357.2

Table 4

Visual Injury Rating[1] of Air Pollution-Induced Symptoms on Silver Maple[2] Foliage Collected during July in the Vicinity of Allied Chemical, Amherstburg[3]

1981 - 1986

Sample Station Number	Foliar Injury Severity					
	1981	1982	1983	1984	1985	1986
16	L	L	Tr	Tr	Tr	Tr
18	L	Tr	Tr	Tr	0	0
29	L	Tr	Tr	Tr	0	Tr
30	Tr	L	Tr	Tr	Tr	0
31	M	L	Tr	L	Tr	Tr
1	L	Tr	Tr	M-S	Tr	Tr
32	-	-	Tr	-	0	0
33	0	0	0	0	0	0

0	-	0%
Trace	-	>0-1%
Light	-	2-10%
Moderate	-	11-35%
Severe	-	>35%

[1]Value represents total injury - no differentiation has been made between fluoride and/or salt symptomatology

[2]Manitoba maple sampled at stations 33 and 32

[3]Control locations 12 and 50 not included

RE1357.3

Table 5

Visual Injury Rating[1] of Air Pollution-Induced Symptoms on Silver Maple[2] Foliage Collected during August in the Vicinity of Allied Chemical, Amherstburg[3]

1981 - 1986

Sample Station Number	Foliar Injury Severity					
	1981	1982	1983	1984	1985	1986
16	L	M	Tr	L	M	L
18	L	L	Tr	Tr	L	0
29	Tr	M	L	L	L	L
30	Tr	L	Tr	L	Tr	0
31	L-M	L	M	S	M	Tr
1	Tr-L	L	0	L-M	L	Tr
32	-	-	0	Tr	Tr	0
33	0	Tr	0	0	Tr	0

0	-	0%
Trace	-	>0-1%
Light	-	2 - 10%
Moderate	-	11 - 35%
Severe	-	>35%

[1]Value represents total injury - no differentiation has been made between fluoride and/or salt symptomatology

[2]Manitoba maple sampled at stations 33 and 32

[3]Control locations 12 and 50 not included

RE1357.4

Table 6

Visual Injury Rating[1] of Air Pollution-Induced Symptoms on Silver Maple[2] Foliage Collected during September in the Vicinity of Allied Chemical, Amherstburg[3]

1981 - 1986

Sample Station Number	Foliar Injury Severity					
	1981	1982	1983	1984	1985	1986
16	L-M	M	Tr	L-M	L-M	M
18	Tr-L	L	Tr	Tr	Tr	Tr
29	Tr-L	M	L	Tr	Tr	0
30	Tr	L	0	L	Tr	0
31	L	M	L	S	L	L
1	Tr	L	Tr	L	Tr	0
32	0	Tr	Tr	Tr	Tr	Tr
33	0	Tr	Tr	Tr	Tr	0

0	-	0%
Trace	-	>0-1%
Light	-	2-10%
Moderate	-	11-35%
Severe	-	>35%

[1]Value represents total injury - no differentiation has been made between fluoride and/or salt symptomatology

[2]Manitoba maple sampled at stations 33 and 32

[3]Control locations 12 and 50 not included

RE1357.5

TABLE 7

Fluoride Content (ppm, dry weight) of Washed and Not Washed Silver Maple Foliage Collected Monthly from May to September 1986 in the Vicinity of ACCL, Amherstburg

Station Number	Sample Location	May 28		July 2		August 1		September 4		October 2		Average of Monthly Results	
		W	NW	W	NW	W	NW	W	NW	W	NW	W	NW
16	Brunner & Balaclava	24	74	34	76	20	39	93	80	64	63	47	66
18	Hwy. 18 & Grant	19	70	36	67	28	50	113	116	52	58	50	72
29	MOE Water Treatment Plant	29	41	25	57	13	21	76	85	16	18	32	44
30	113 Texas Road	47	59	24	34	19	28	54	84	33	44	35	50
31	215 Texas Road	53	82	37	74	26	54	50	91	44	67	42	74
1	326 Texas Road	70	81	98	180	140	274	191	263	270	250	154	210
32	465 Texas Road	9	11	31	56	23	36	40	60	49	57	30	44
33[1]	Texas Road & 2nd. Conc.	10	20	7	20	14	34	45	57	45	46	24	35
MEAN		33	55	37	71	35	67	83	105	72	75	52	74
Controls													
12	Alma Road & 3rd Conc., Malden	4	6	15	26	13	21	30	39	43	46	21	28
50[1]	North Sdrd & 4th Conc., Anderdon	3	4	8	15	9	16	16	23	37	36	15	19

TABLE 8

Fluoride Content (ppm, dry weight) of Not-Washed Grass Samples Collected Monthly from the end of April to the end of October 1986 in the Vicinity of ACCL, Amherstburg

Station Number	Sample Location	Grass Surveillance Dates							Average of Monthly Results
		April 29	May 28	July 2	August 1	Sept. 4	October 2	October 29	
16	Brunner & Balaclava	105	16	26	10	170	43	52	60
18	Hwy. 18 & Grant	33	12	14	21	74	33	34	32
29	MOE Water Treatment Plant	37	12	20	8	84	21	28	30
30	113 Texas Road	43	9	7	5	51	7	30	22
31	215 Texas Road	69	20	11	23	46	11	14	28
1	326 Texas Road	60	7	23	26	87	39	64	44
32	465 Texas Road	92	4	11	14	42	9	25	28
33[1]	Texas Road & 2nd. Conc.	28	3	4	5	61	32	21	22
MEAN		58	10	15	14	77	24	34	33
Controls									
12	Alma Road & 3rd Conc., Malden	24	2	8	5	31	29	9	15
50[1]	North Sdrd & 4th Conc., Anderdon	4	<1	<1	1	8	30	7	7

TABLE 9

Number of Fluoride Exceedences of the Former Control Order found in Not Washed Grass and Washed Maple Foliage Collected in the Vicinity of ACCL

1980-1986

Year	Grass	Maple Foliage
1980	15	0
1981	1	1
1982	2	0
1983	15	7
1984	0	5
1985	9	6
1986	0	4

RE1357.10

Table 10

Specifications of Former[1] Control Order Applied to Fluoride Values Found in Grasses Collected in 1985 and 1986 at 8[2] Established Sample Sites in the Vicinity of Allied Chemical Canada Limited, Amherstburg

1985

Former Control Order	Data for Sites with Fluoride Exceedences		
	Sample Location	Sampling Date	Average
80 ppm[3]	16	April 30 - May 30	89
	1	April 30 - May 30	101
	1	August 28 - October 2	98
	1	October 2 - November 4	128
60 ppm[4]	16	April 30, May 30, July 2	82
	1	April 30, May 30, July 2	81
	16	May 30, July 2, July 31	61
	1	July 31, August 28, October 2	81
	1	August 28, October 2, November 4	112

1986

Former Control Order	Sample Location	Sampling Date	Average
80 ppm[3]	-	No exceedances	-
60 ppm[4]	-	No exceedances	-

[1]Applied in 1980 but rescinded prior to the 1981 field season

[2]Control stations 12 and 50 not included.

[3]Fluoride levels were not to exceed 80 ppm in not-washed grasses on a monthly average. (Average of two samplings near the beginning and end of the month.)

[4]Fluoride levels were not to exceed 60 ppm in not-washed grasses on a two-consecutive-month average. (Average of 3 samplings.)

RE1357.11

TABLE 11

Specifications of Former[1] Control Order Applied to Fluoride Values Found in Washed Silver Maple Collected in 1985 and 1986 at 8[2] Established Sample Sites in the Vicinity of Allied Chemical Canada Limited, Amherstburg

1985

Former Control Order	Data for Sites with Fluoride Exceedences		
	Sample Location	Sampling Date	Fluoride Value
100 ppm[4]	1	May 30	218
	1	July 2	100
	1	July 31	144
	16	August 28	105
	16	October 2	107
	1	October 2	225

1986

Former Control Order	Data for Sites with Fluroide Exceedences		
	Sample Location	Sampling Date	Fluoride Value
100 ppm[4]	1	August 1	140
	1	September 4	191
	1	October 2	270
	18	September 4	113

[1]Applied in 1980 but rescinded prior to the 1981 field season.

[2]Control stations 12 and 50 not included.

[3]Parts per million - dry weight

[4]Fluoride concentration not to exceed 100 ppm in any one monthly sampling in washed vegetation.

RE1357.12

Table 12

Fluoride Exceedences of the Phytotoxicology Guideline[1] in Not-Washed Urban Maple Foliage at 8[2] Established Sample Sites in the Vicinity of Allied Chemical Canada Limited, Amherstburg

1986

	Fluoride Values[3] Exceeding 35 ppm					
Sample Location	May 30	July 2	August 1	September 4	October 2	TOTAL No. Exceedences
16	-	-	-	93	64	2
18	-	36	-	113	52	3
29	-	-	-	76	-	1
30	47	-	-	54	-	2
31	53	37	-	50	44	4
1	70	98	140	191	270	5
32	-	-	-	40	49	2
33	-	-	-	45	45	2
Total No. Exceedences	3/8	3/8	1/8	8/8	6/8	21/40

[1]Levels above the 35 ppm upper limits of normal.

[2]Control stations 12 and 50 not included.

[3]Parts per million - dry weight.

RE1357.13

Table 13

Fluoride Exceedences of the Phytotoxicology Guideline[1] in Not-Washed Urban Maple Foliage at 8[2] Established Sample Sites in the Vicinity of Allied Chemical Canada Limited, Amherstburg

1985

	Fluoride Values[3] Exceeding 35 ppm					
Sample Location	May 30	July 2	July 31	August 28	October 2	TOTAL No. Exceedences
16	186	129	162	259	173	5
18	71	100	55	71	98	5
29	135	40	104	68	102	5
30	70	-	58	42	79	4
31	87	68	138	166	91	5
1	327	123	215	129	315	5
32	-	56	46	56	74	4
33	-	-	-	-	36	1
Total No. Exceedences	6/8	6/8	7/8	7/8	8/8	34/40

[1]Levels above the 35 ppm upper limits of normal.

[2]Control stations 12 and 50 not included.

[3]Parts per million - dry weight.

RE1357.14

TABLE 14

Fluroide Exceedances of the Phytotoxicology Guideline[1] in Not-Washed Urban Maple Foliage at 8[2] Established Sample Sites in the Vicinity of Allied Chemical Canada Limited Amherstburg

1984

	Fluoride Values[3] Exceeding 35 ppm					
Sample Location	May 31	July 6	August 2	August 29	October 2	TOTAL No. Exceedences
16	-	74	59	54	61	4
18	-	58	59	59	61	4
29	-	51	82	92	82	4
30	-	-	-	-	-	0
31	-	95	167	99	98	4
1	187	280	430	290	406	5
32	-	37	61	50	86	4
33	-	-	-	-	40	1
Total No. Exceedences	1/8	6/8	6/8	6/8	7/8	26/40

[1]Levels above the 35 ppm upper limits of normal.

[2]Control stations 12 and 50 not included.

[3]Parts per million - dry weight.

RE1357.15

TABLE 15

Number of Fluoride Exceedances of the Phytotoxicology Upper Limit of Normal Guideline[1] Found in Not-washed Silver Maple[2] at 8[3] Sample Sites in the Vicinity of Allied Chemical Canada Limited, Amherstburg

1984 - 1986

	Sample Site								Total Number of Exceedences
Year	16	18	29	30	31	1	32	33	
1984	4	4	4	0	4	5	4	1	26
1985	5	5	5	4	5	5	4	1	34
1986	2	3	1	2	4	5	2	2	21
Total No. Exceedences	11/15	12/15	10/15	6/15	14/15	15/15	10/15	4/15	

[1]35 ppm - dry weight

[2]Manitoba maple sampled at site 33

[3]Control stations 12 and 50 not included

RE1357.16

TABLE 16

Fluoride Content of Washed Silver Maple Foliage Collected in the Vicinity of A.C.C.L. Near the End of May from 1975 to 1986

Sample Station Number	Fluoride Content (ppm-dry weight)												
	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1975-1984[1]	1986
	May 28	May 31	May 26	May 29	May 31	May 29	May 29	June 5	June 3	May 31	May 30	Average	May 28
16	54	163	84	-	14	100	57	14	17	10	39	55	24
18	19	78	84	-	6	33	9	25	20	16	21	31	19
29	79	24	85	-	11	12	11	28	30	20	45	35	29
30	47	20	46	-	51	12	15	29	9	11	24	26	47
31	36	42	73	-	28	108	15	62	62	17	43	49	53
1	161	49	41	-	17	15	10	33	15	166	218	73	70
32	-	-	-	-	-	-	-	-	3	8	23	11	9
33[2]	-	-	-	-	-	-	3	15	23	15	12	14	10
Average of year	66	63	69	-	21	47	20[3]	32[3]	26[4]	40[4]	65[4]	49[4]	40[4]
Controls													
12	-	-	-	-	-	5	6	14	12	10	7	9	4
50[2]	-	-	-	-	-	-	3	12	20	6	5	9	3

[1]Data from 1978 not included
[2]Manitoba Maple (Stations 33 and 50)
[3]Station 33 values not included in the average
[4]Stations 33 and 32 values not included in the average

RE1357.18

TABLE 17

Fluoride Content of Washed Silver Maple Foliage Collected in the Vicinity of A.C.C.L. Near the End of June from 1975 to 1986

Sample Station Number	Fluoride Content (ppm-dry weight)												
	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1975-1984	1986
	July 2	June 29	June 29	June 29	June 28	June 26	July 2	June 30	July 4	July 6	July 2	Average	July 2
16	131	32	54	18	34	22	62	24	17	20	54	43	34
18	24	50	33	8	21	14	42	17	11	17	39	25	36
29	43	34	79	48	29	46	40	16	34	22	21	37	25
30	32	18	32	23	51	28	20	20	9	8	14	23	24
31	68	26	45	31	95	114	30	58	150	55	45	65	37
1	72	75	39	78	191	76	85	34	55	213	100	93	98
32	-	-	-	-	-	-	-	-	8	26	40	25	31
33[1]	-	-	-	-	-	-	10	8	12	6	9	9	7
Average of year	62	39	47	34	70	50	47[2]	28[2]	46[2]	56[2]	46[3]	48[3]	42[3]
Controls													
12	-	-	-	-	-	10	10	20	5	8	7	10	15
50[1]	-	-	-	-	-	-	10	12	5	5	7	8	8

[1]Manitoba Maple (Stations 33 and 50)
[2]Station 33 values not included in the average
[3]Stations 33 and 32 values not included in the average

RE1357.20

TABLE 18

Fluoride Content of Washed Silver Maple Foliage Collected in the Vicinity of A.C.C.L. Near the End of July from 1975 to 1986

	Fluoride Content (ppm-dry weight)												
Sample Station Number	1975 July 30	1976 July 28	1977 July 28	1978 July 27	1979 Aug. 2	1980 July 31	1981 July 28	1982 July 27	1983 Aug. 2	1984 Aug. 2	1985 July 31	1975-1985 Average	1986 Aug. 1
16	151	39	48	21	40	15	46	50	25	27	59	52	20
18	39	47	35	13	35	14	20	25	22	26	24	27	28
29	225	83	60	29	32	30	40	41	49	38	51	62	13
30	61	16	35	34	42	13	10	31	32	21	30	27	19
31	187	28	44	47	111	45	35	48	89	68	73	70	26
1	191	71	42	64	144	72	38	50	158	264	144	113	140
32	-	-	-	-	-	-	-	-	25	41	32	33	23
33[1]	-	-	-	-	-	-	10	15	7	16	14	12	14
Average of year	142	47	44	35	87	32	32[2]	41[2]	63[3]	74[3]	64[3]	60[3]	41[3]
Controls													
12	-	-	-	-	9	-	20	11	10	12	10	12	13
50[1]	-	-	-	-	-	-	5	11	9	9	8	8	9

[1]Manitoba Maple (Stations 33 and 50)
[2]Station 33 values not included in the average
[3]Stations 33 and 32 values not included in the average

RE1357.22

TABLE 19

Fluoride Content of Washed Silver Maple Foliage Collected in the Vicinity of A.C.C.L. Near the End of August from 1975 to 1986

Sample Station Number	Fluoride Content (ppm-dry weight)												
	1975 Aug. 27	1976 Aug. 31	1977 Sept. 1	1978 Aug. 31	1979 Aug. 30	1980 Aug. 28	1981 Aug. 31	1982 Sept. 1	1983 Sept. 6	1984 Aug. 29	1985 Aug. 28	1975-1985 Average	1986
16	167	153	49	43	156	30	26	62	51	20	105	78	93
18	42	59	53	25	77	34	50	27	55	40	39	46	113
29	125	137	126	36	61	84	58	58	65	47	55	77	76
30	46	35	44	30	63	55	30	24	45	15	18	37	54
31	113	66	59	48	135	118	26	31	240	40	98	89	50
1	185	129	113	195	265	143	55	46	86	138	60	129	191
32	-	-	-	-	-	-	-	-	39	43	47	43	40
33[1]	-	-	-	-	-	-	25	12	16	9	20	16	45
Average of year	113	96	74	63	126	77	41[2]	41[2]	90[3]	50[3]	63[3]	76[3]	96[3]
Controls													
12	-	-	-	-	-	22	22	18	19	14	15	18	30
50[1]	-	-	-	-	-	-	20	10	23	11	11	15	16

[1]Manitoba Maple (Stations 33 and 50)
[2]Station 33 values not included in the average
[3]Stations 33 and 32 values not included in the average

RE1357.24

TABLE 20

Fluoride Content of Washed Silver Maple Foliage Collected in the Vicinity of A.C.C.L. Near the End of September from 1975 to 1986

Sample Station Number	Fluoride Content (ppm-dry weight)												
	1975 Sept. 29	1976 Sept. 30	1977 Sept. 28	1978 Sept. 27	1979 Sept. 27	1980 Oct. 2	1981 Oct. 1	1982 Sept. 29	1983 Oct. 3	1984 Oct. 3	1985 Oct. 2	1975-1985 Average	1986 Oct. 2
16	208	110	91	157	198	28	74	66	117	38	107	109	64
18	47	33	46	53	98	36	38	33	99	51	61	54	52
29	97	59	64	108	65	45	48	86	147	65	59	77	17
30	66	20	40	62	49	53	12	32	76	23	40	43	33
31	165	31	43	51	168	107	30	74	160	72	60	87	44
1	172	141	88	181	282	147	76	92	447	317	225	197	270
32	-	-	-	-	-	-	-	-	66	71	48	62	49
33[1]	-	-	-	-	-	-	22	20	33	32	26	27	45
Average of year	126	66	62	102	143	69	46[2]	64[2]	174[3]	84[3]	92[3]	95[3]	80[3]
Controls													
12	-	-	-	-	-	22	14	43	26	24	22	25	43
50[1]	-	-	-	-	-	-	14	16	22	11	17	16	37

[1]Manitoba Maple (Stations 33 and 50)
[2]Station 33 values not included in the average
[3]Stations 33 and 32 values not included in the average

RE1357.26

TABLE 21

Comparative Average Fluoride Values (ppm, dry weight) in Washed Silver Maple Foliage Collected in the Amherstburg Area

1981 - 1986

Sample Month	1981	1982	1983	1984	1985	1986	1981-1985 Average
May	20	32	26	40	65	40	37
June	47	28	46	56	46	42	45
July	32	41	63	74	64	41	55
August	41	41	90	50	63	96	57
September	46	64	174	94	92	80	94
Average by year	37	41	80	63	66	60	57

[1]Average Fluoride value of 6 sample sites - stations 33, 32 and control sites 12 and 50 have not been included.

RE1357.27

TABLE 22

Average Levels of Fluoride (ppm, dry weight) found in Maple Foliage from 1975 to 1986 and in Grass (1982-1986) Collected at 8 Sample Locations near ACCL, Amherstburg

Year	No. of Samples (Maple)	Average Fluoride Concentration		Ratio NW/W
		Washed (W)	Not Washed (NW)	
1975	30	102	168	1:6
1976	30	62	127	2:0
1977	30	59	117	2:0
1978	24[1]	58	125	2:2
1979	30	86	158	1:8
1980	30	55	114	2:1
1981	35	37	72	2:1
1982	35	41	64	1:6
1983	120	80	124	1:6
1984	120	54	101	1:9
1985	120	56	102	1:8
1975-85 Averages		63	116	1:8
1986 (Maple	120	52	75	1:4
Grasses				
1982	56	-	35[2]	-
1983	152	-	43[2]	-
1984	168	-	25[2]	-
1985	168	-	40[2]	-
1986	168	-	33[2]	-

[1]May data not available.

[2]Average for grass samples collected from the same stations as the maple foliage.

Control station data are not included.